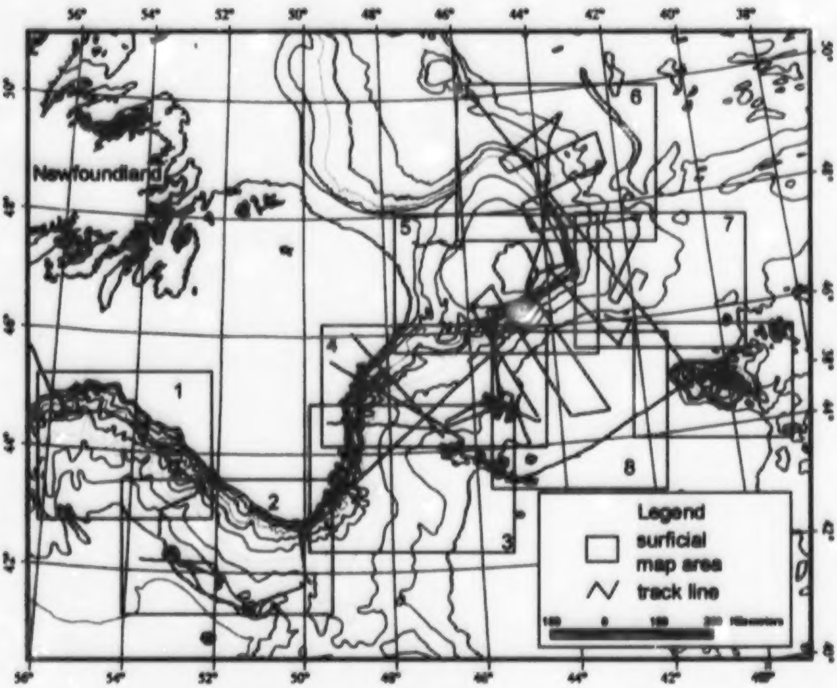
Geological Survey of Canada Open File 3762

# Acoustic evidence for shallow gas and seabed classification along selected ship tracks on the deep-water margin of the Grand Banks of Newfoundland




by G.D.M. Cameron[1]

*This open file consists of an Arc-view data base, 9 maps and a short illustrated report. It describes the distribution of acoustic evidence for shallow gas and for the type of seabed sediment on the deep-water continental margin of the Grand Banks of Newfoundland.*

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Open File report prepared for release by D.C. Campbell and D.J.W. Piper March, 2000

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# Contents

**Introduction**

The deep-water margin off the Grand Banks of Newfoundland is a poorly known area of seafloor. On other deep-water margins off eastern Canada, such as the Scotian Slope and Orphan Basin, there is widespread evidence for sediment instability (Mulder et al. 1997; Hiscott and Aksu, 1996). There is circumstantial evidence that much of this instability is linked to the presence of gas hydrates (Piper et al. 1999b). A regional understanding of slope instability is required if the general origin of slope instability on the eastern Canadian margin and the significance of local variations are to be understood. This Open File report describes and maps evidence for shallow gas and various instability features from all the 3.5 kHz seabed profiles available at GSC(A) on the Grand Banks margin, with the exception of some profiles from St Pierre Slope (see Piper et al. 1985b, 1999a) and Flemish Pass (see Pereira et al. 1985; Armstrong et al. 1988; Piper and Pereira 1992).

**Methods**

This study utilized 3.5 kHz sub-bottom profiler data, from the Laurentian Channel to Northeast Newfoundland Shelf, and from the shelf break to beyond the 4000 m isobath. These data are from GSC(A) cruises 90007, 91020 and 92022, and represent approximately 5000 line kilometers of coverage (see map on title page).

Surface and near surface sediment character and features were interpreted and classified according to the classification detailed in Table 1. The resulting sea floor classification was then entered into an Excel spreadsheet, combined with navigation files in ArcInfo and line attributes were assigned. These ArcInfo files were imported into ArcView where they were transformed into maps.

The 3.5 kHz data are generally of good quality. The hull mounted 3.5 kHz transducer has a large acoustic foot print or first Fresnel zone in deep water. This limits the horizontal resolution that can be expected from the acoustic reflection method. Sea floor geometry and vertical exaggeration were additional problems with the 3.5 kHz profiles. Areas of complex geological structure and seabed relief can produce distorted seismic profiles from which it is difficult to deduce the correct geometry of the corresponding geological section, thus limiting definitive interpretation (figure 1). These problems were kept in mind during the interpretation of all acoustic profiles.

**Seabed and subsurface acoustic character**

Description of the acoustic character seen in 3.5 kHz profiles focused on the recognition of seabed instability features. Much of the continental slope consists of well stratified muddy surficial sediment. Greater amounts of sand generally result in poorer stratification. Locally, stratified sediments have been eroded, either from current action (commonly in valleys) or sediment failure (cf. Piper et al. 1985a). On the lower slope and rise, debris flow deposits can be recognised from their tendency to fill depressions, their acoustically amorphous character, and the common occurence of a rough surface with reflective sediment in some depressions (cf. Berry, 1992; Piper et al. 1995). Areas of hummocky terrain may be largely erosional on the upper slope, but probably represent flow slides on the lower slope and rise. In general, the upper 1-2 m of seabed sediment represents Holocene and latest Pleistocene "post-glacial" sedimentation whereas deeper sediments accumulated largely under "glacial" conditions. In places, such as over debris flows, the surface sediment is of sufficiently distinctive character (e.g., transparent, interpreted as a mud drape; high amplitude reflection, interpreted as a sand sheet) to be noted.

For the most part, the surface acoustic character varied little from the subsurface acoustic character. Therefore the interpreted seabed geology is presented as a single coloured line along track. It should be mentioned that, in some areas, the surface may obscure the subsurface because of the simplified classification.

**Seabed morphology**

The seafloor classification scheme used in this report is shown in Table 1. Features appearing in bold are presented on the seabed maps. This report also includes illustrative figures which show type sections of several seabed morphological features and are referenced in Table 1.

**Evidence of shallow gas**

Several acoustic features in 3.5 kHz profiles may be evidence of shallow gas. These include patchy acoustic wipeouts, subvertical reflective zones, and patchy high-amplitude reflections. The former two features may also be produced as artefacts by acoustic focusing, and patchy high-amplitude reflections may result from lateral subsurface variation in sand distribution. 3.5 kHz profile indicators of shallow gas are common on St Pierre Slope, where pockmarks and gassy cores have been recovered (Piper et al. 1985b, 1999a). These indicators have not been noted on the continental rise off the Grand Banks. More rigorous ground-truthing of these features is planned for summer 1999. The reader should use caution in interpreting their significance.

**Maps and Digital Products**

The nine hard copy maps accompanying this report are presented on the Basin Atlas bathymetric base (contour intervals of 500m) using Lambert Conformal Conic Projection and the standard parallels 45°N and 66°N. The ArcView database includes a more detailed derivation of the Basin Atlas bathymetry for the study area. ESRI, the manufacturer of ArcView, has made available a free GIS data explorer called ArcExplorer which can be downloaded at

www.esri.com/software/arcexplorer/index.html

The along track data can be viewed and queried with ArcExplorer if ArcView is unavailable.

**References**


Armstrong, R., Piper, D.J.W. and Pereira, C.G.P. 1988. Pleistocene stratigraphy and sedimentation of western Flemish Pass: a seismostratigraphic interpretation. Geological Survey of Canada Open File 1741.

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Piper, D.J.W., Sparkes, R., Mosher, D.C., Shor, A.N and Farre, J.A. 1985b. Sediment instability near the epicentre of the 1929 Grand Banks earthquake G.S.C. Open File 1131.

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**Table 1: Sea floor Classification** (features in bold appear on seabed maps)

| Code | Seabed character | Illustrative figure |
|---|---|---|
| s | stratified | |
| **ws** | **well stratified** | Fig. 2, Fig. 3, Fig.4, Fig. 7, Fig. 8 |
| **wse** | **well stratified, eroded** | Fig. 4 |
| wsr | well stratified, reflective | Fig. 21 |
| wsd | well stratified, discontinuous | |
| | | |
| **ps** | **poorly stratified** | |
| **pse** | **poorly stratified, eroded** | |
| ppr | poorly stratified, patchy reflectors | Fig. 10 |
| psd | poorly stratified, discontinuous | |
| | | |
| **sdf** | **smooth debris flow** | Fig. 16 |
| **idf** | **intermediate debris flow*** | Fig. 3, Fig. 7, Fig. 8, Fig. 11, Fig. 13 |
| **rdf** | **rough debris flow*** | |
| | * grouped into debris flow on maps | |
| | | |
| h | hummocky | Fig. 6, Fig. 12 |
| hd | hummocky with diffuse reflectors | |
| u | undulating | Fig. 6 |
| hg | highly gullied or dissected | Fig. 1 |
| ss | steep slope, may obscure bottom type | |
| Surface reflections | | |
| **psr** | **prolonged strong reflector** | Fig. 17 |
| **har** | **high amplitude reflector** | Fig. 5 |
| **t** | **transparent reflector** | Fig. 11 |
| dr | diffuse reflectors | |
| r | reflective | |
| Gas-related features | | |
| **wo** | **wipeout** | Fig. 11, Fig. 15, Fig. 18, Fig. 19 |
| **sr** | **subvertical reflective zone** | Fig. 15, Fig. 18, Fig. 19 |
| **er** | **enhanced reflector** | Fig. 11, Fig. 19 |
| **bs** | **bright spot** | |
| **gm** | **gas masking** | Fig. 11 |
| Morphological features | | |
| d | diapir | Fig. 8 |
| ch | channel | Fig. 2, Fig. 5 |
| sb | slide block | Fig. 14 |
| sf | scarp or scarp face | Fig. 14, Fig. 20 |
| l | levee | Fig. 5, Fig. 20 |
| cf | cut-and-fill feature | Fig. 2 |

**List of maps**

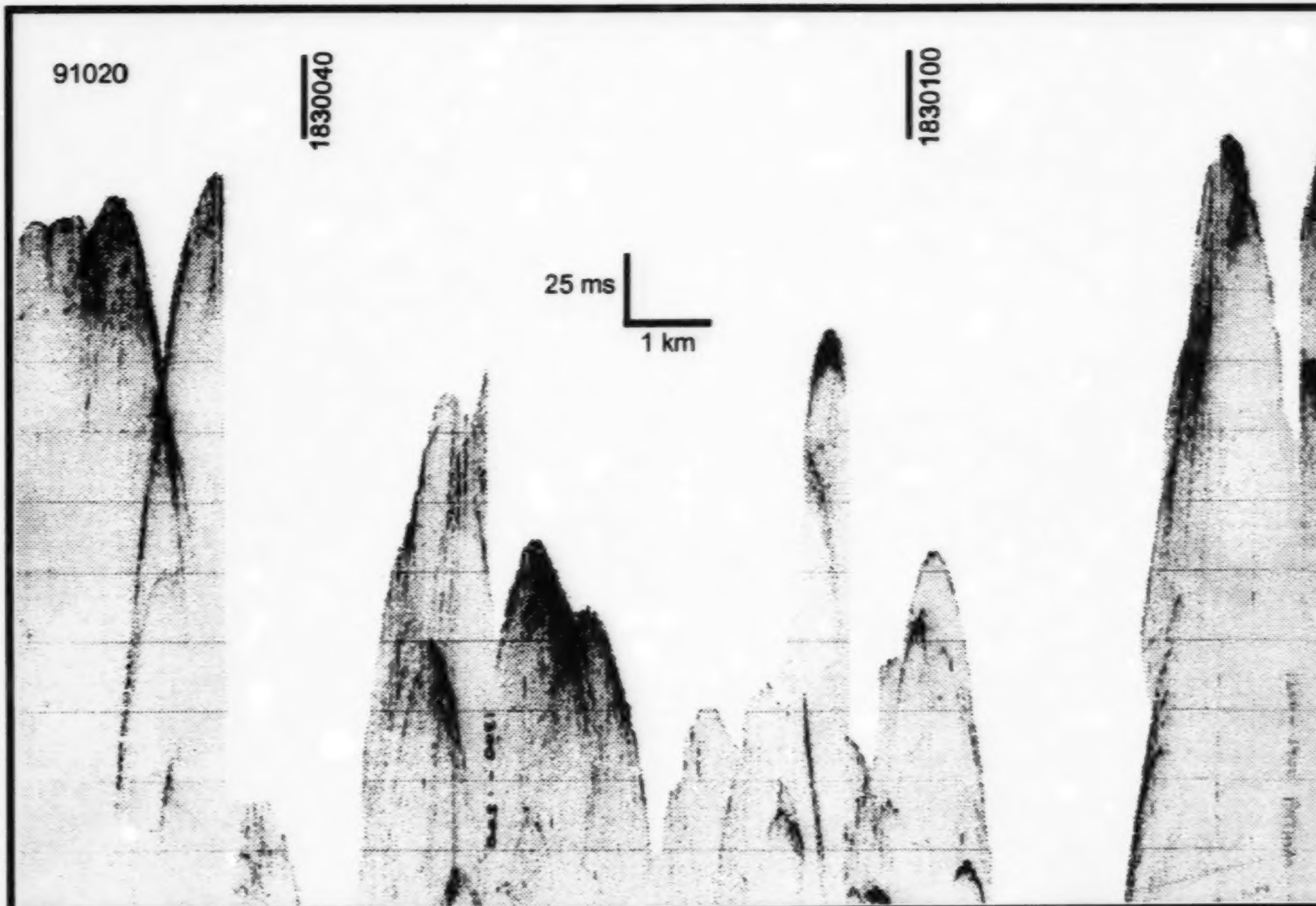


Figure 1   A 3.5 kHz record  showing an area of the seafloor which is highly dissected.

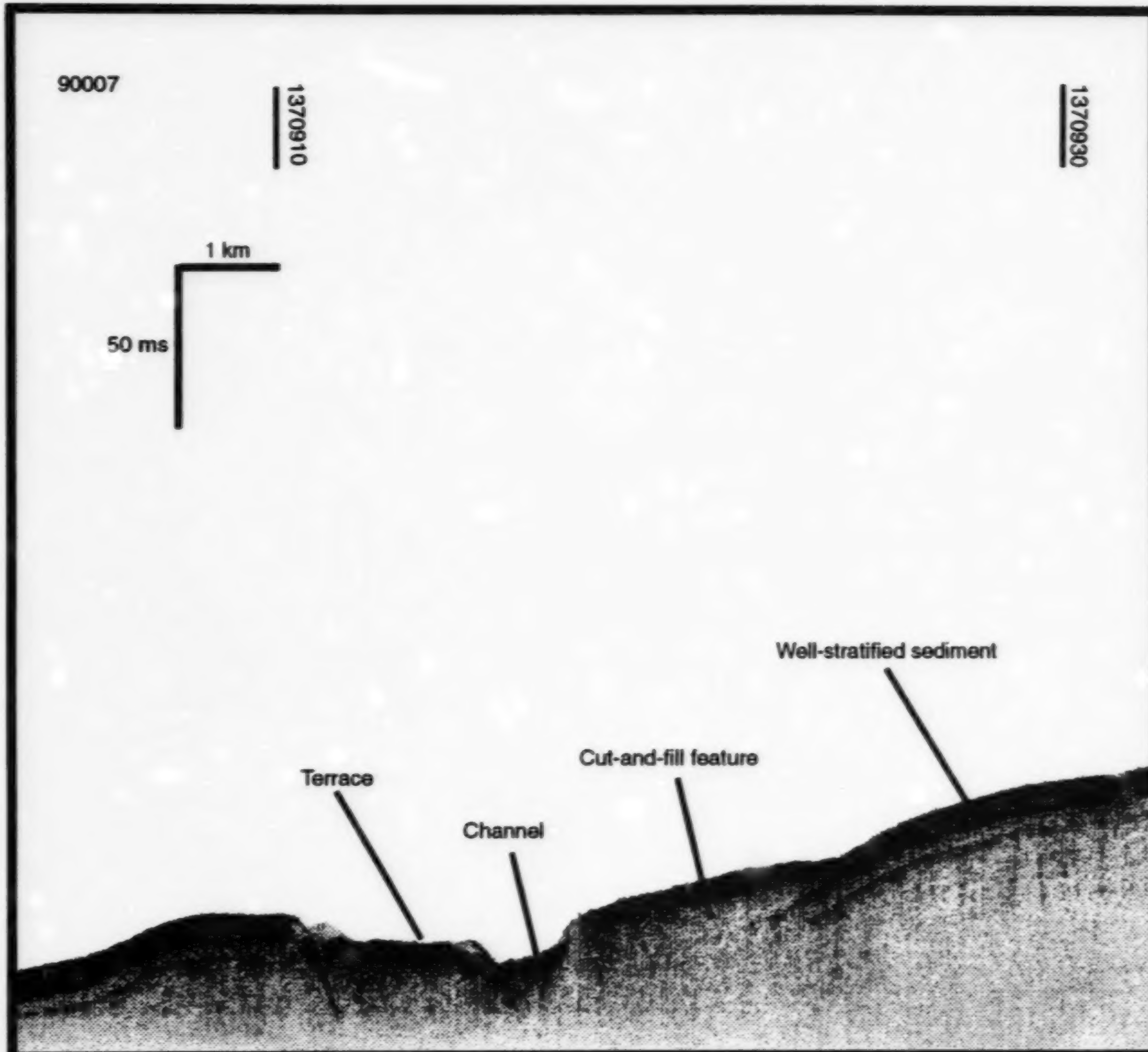


Figure 2 This 3.5 kHz record shows a cut-and-fill feature with a small channel and hummocky reflective terrace in well-stratified sediment.

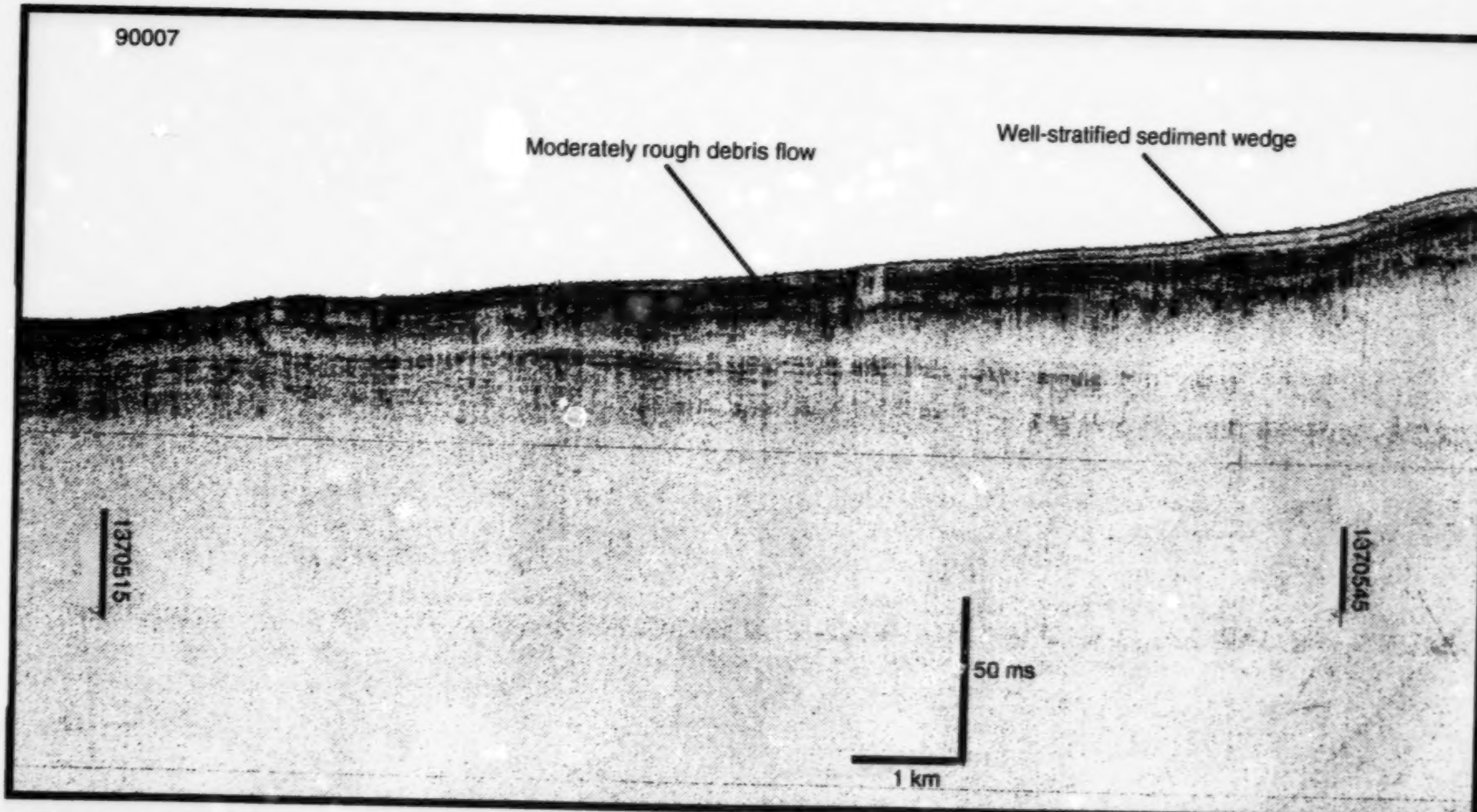


Figure 3 This 3.5 kHz record shows a well-stratified wedge of sediment overlying a moderately rough debris flow. The well-stratified wedge of sediment, which is found at the base of the Milne Seamount, may be a Western Boundary Undercurrent deposit.

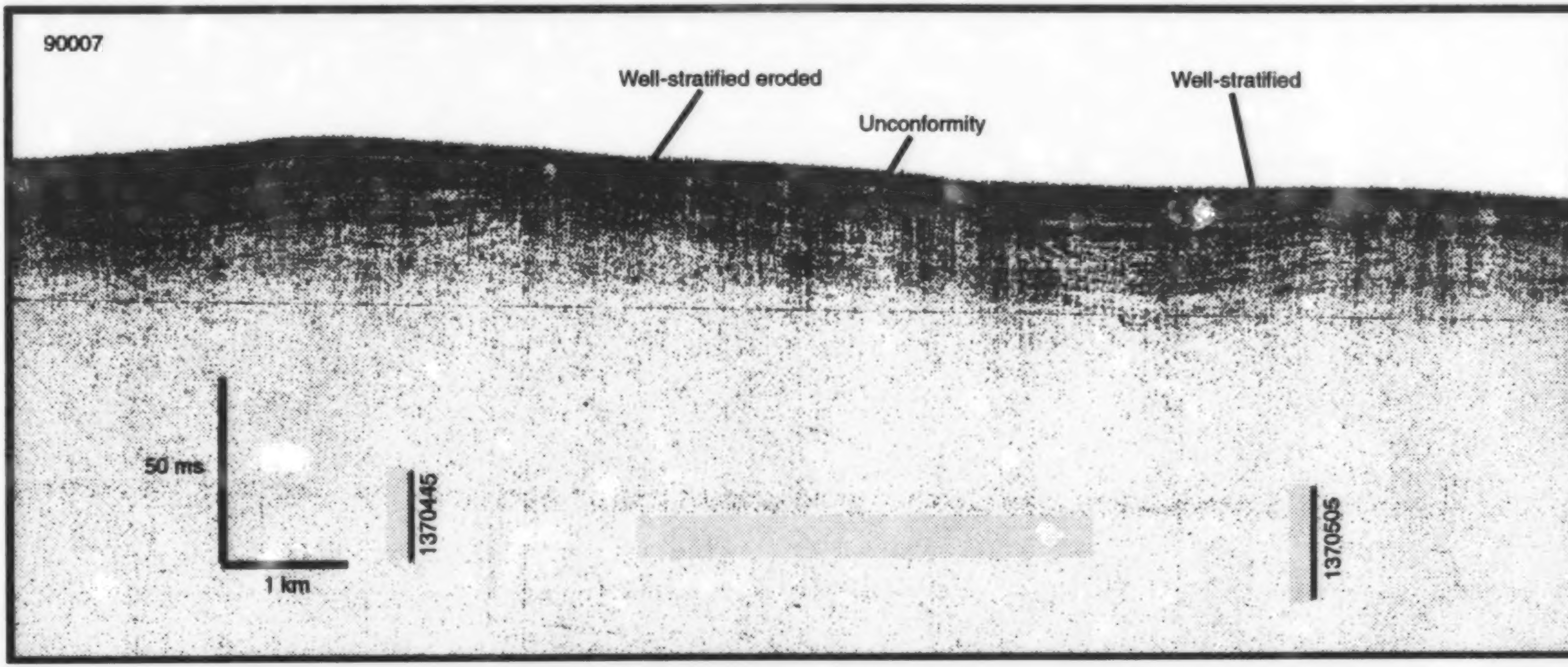


Figure 4 This 3.5 kHz record shows well-stratified sediment overlying well-stratified eroded sediment.

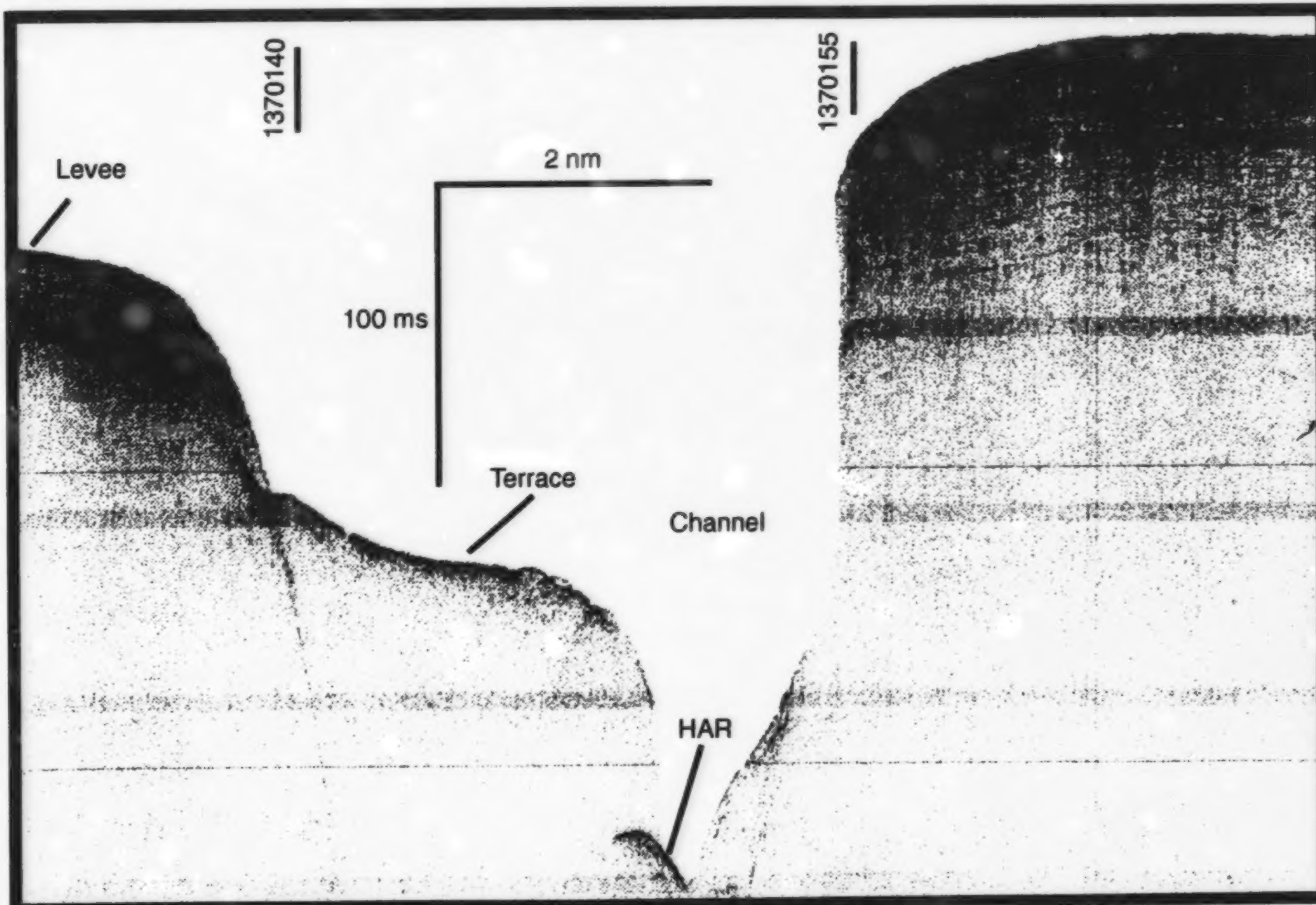


Figure 5 This 3.5 kHz record features Namoc Channel with a hummocky channel floor (HAR=High Amplitude Reflector) and terrace.

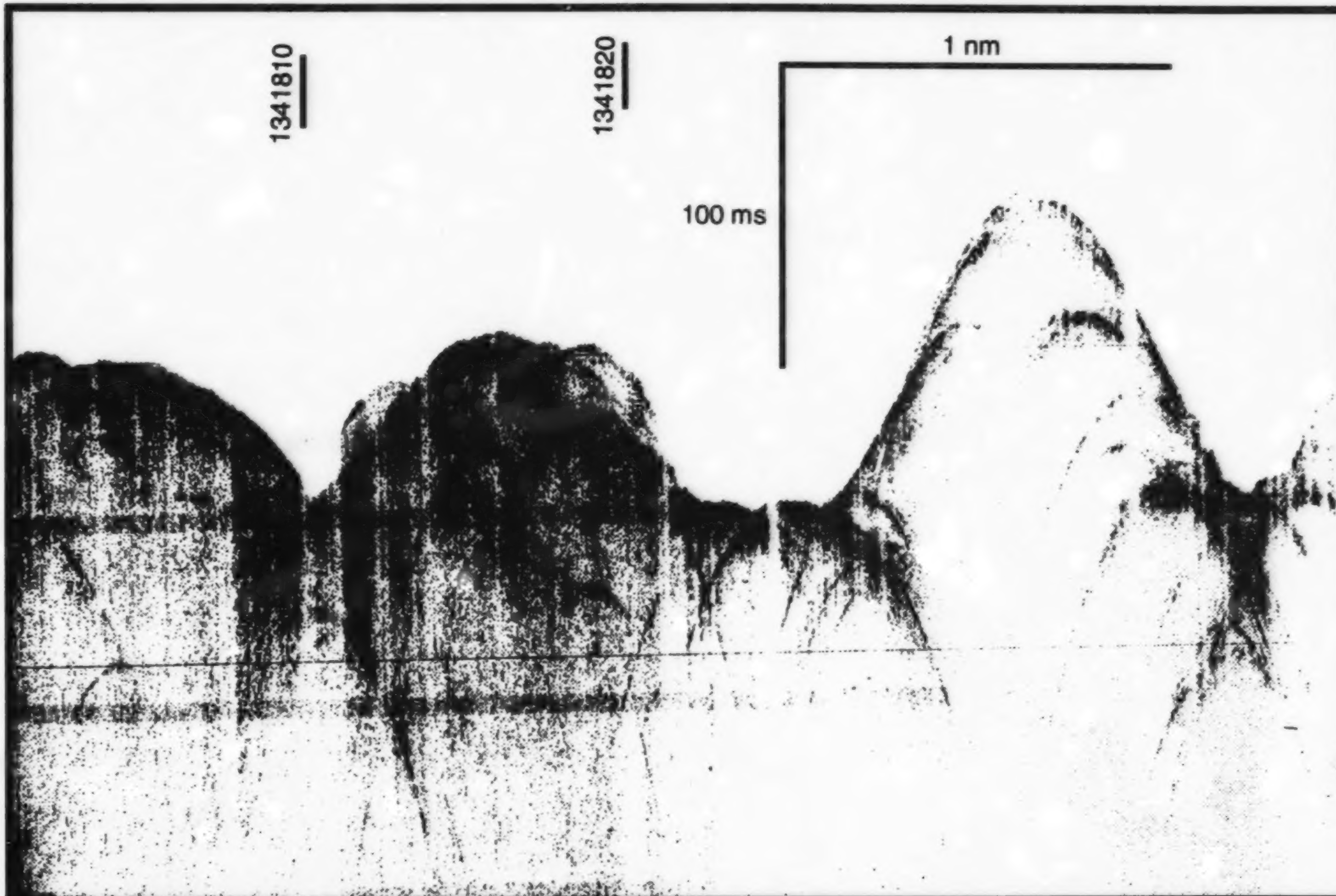


Figure 6 This 3.5 kHz record illustrates very hummocky, undulating terrain near Milne Seamount.

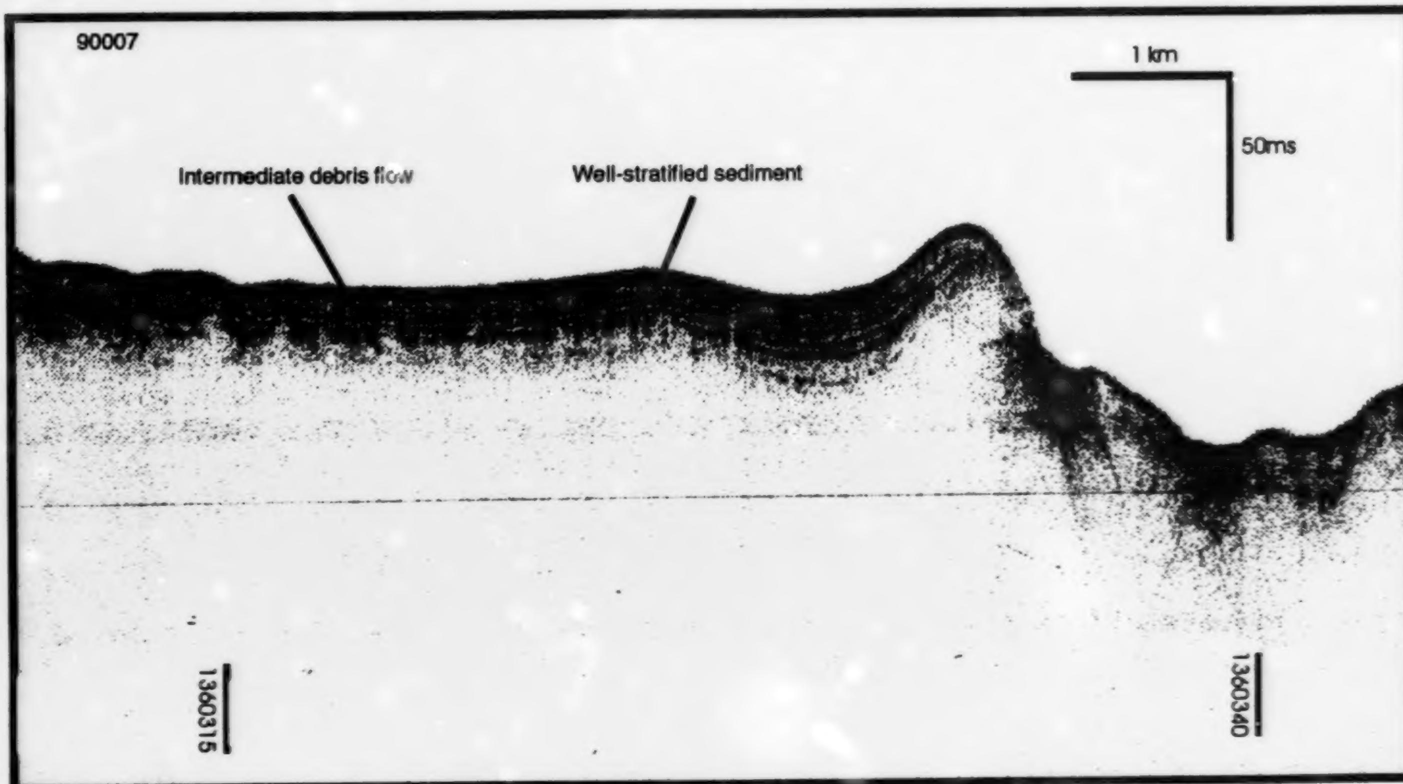


Figure 7 This 3.5 kHz record shows well-stratified sediment overlying an intermediate debris flow, near the base of a seamount. This intermediate debris flow has a similar acoustic appearance as gas masking found on areas of the continental slope.

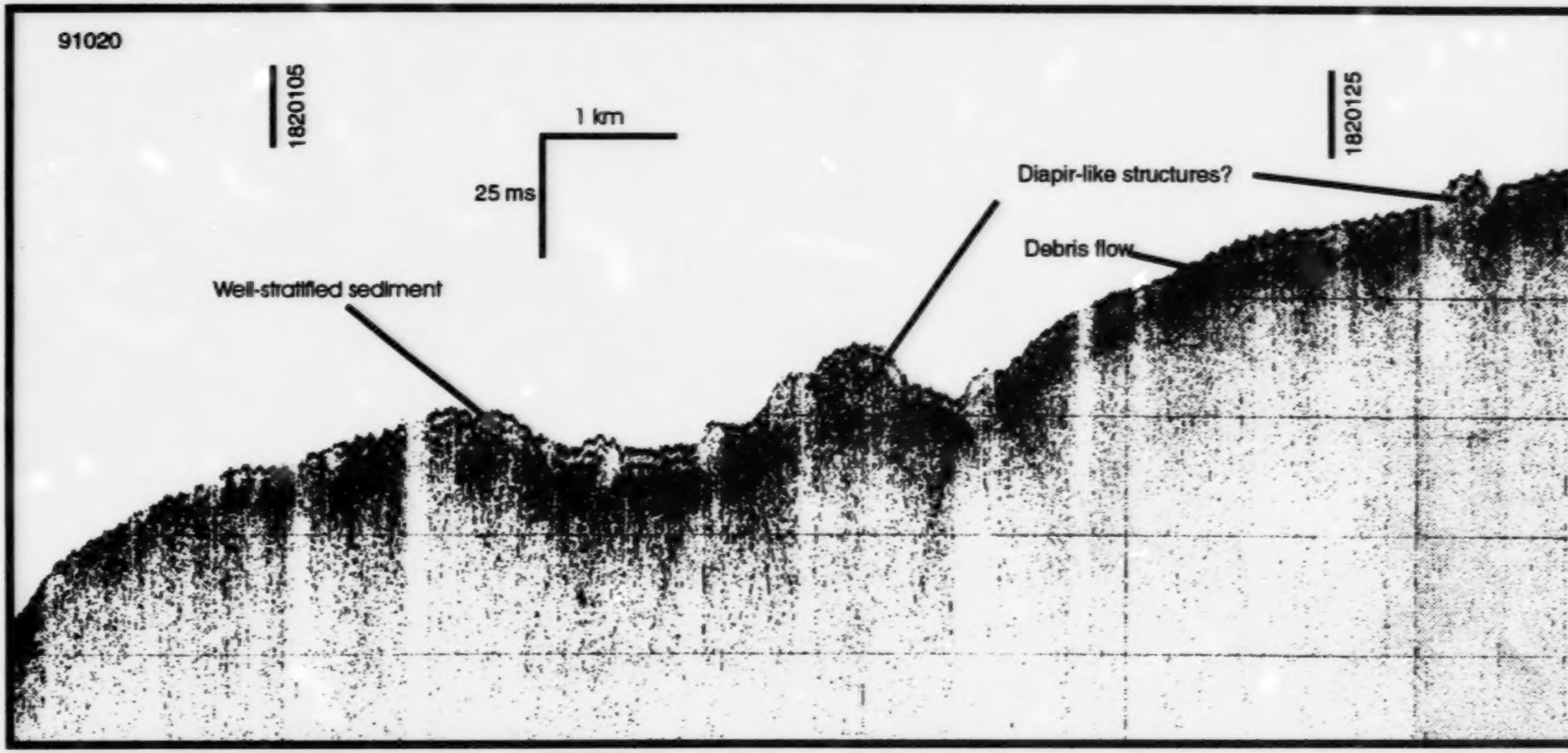


Figure 8 This 3.5 kHz record shows diapir-like structures at the seabed, which may have intruded into overlying sediment from the underlying debris flow.

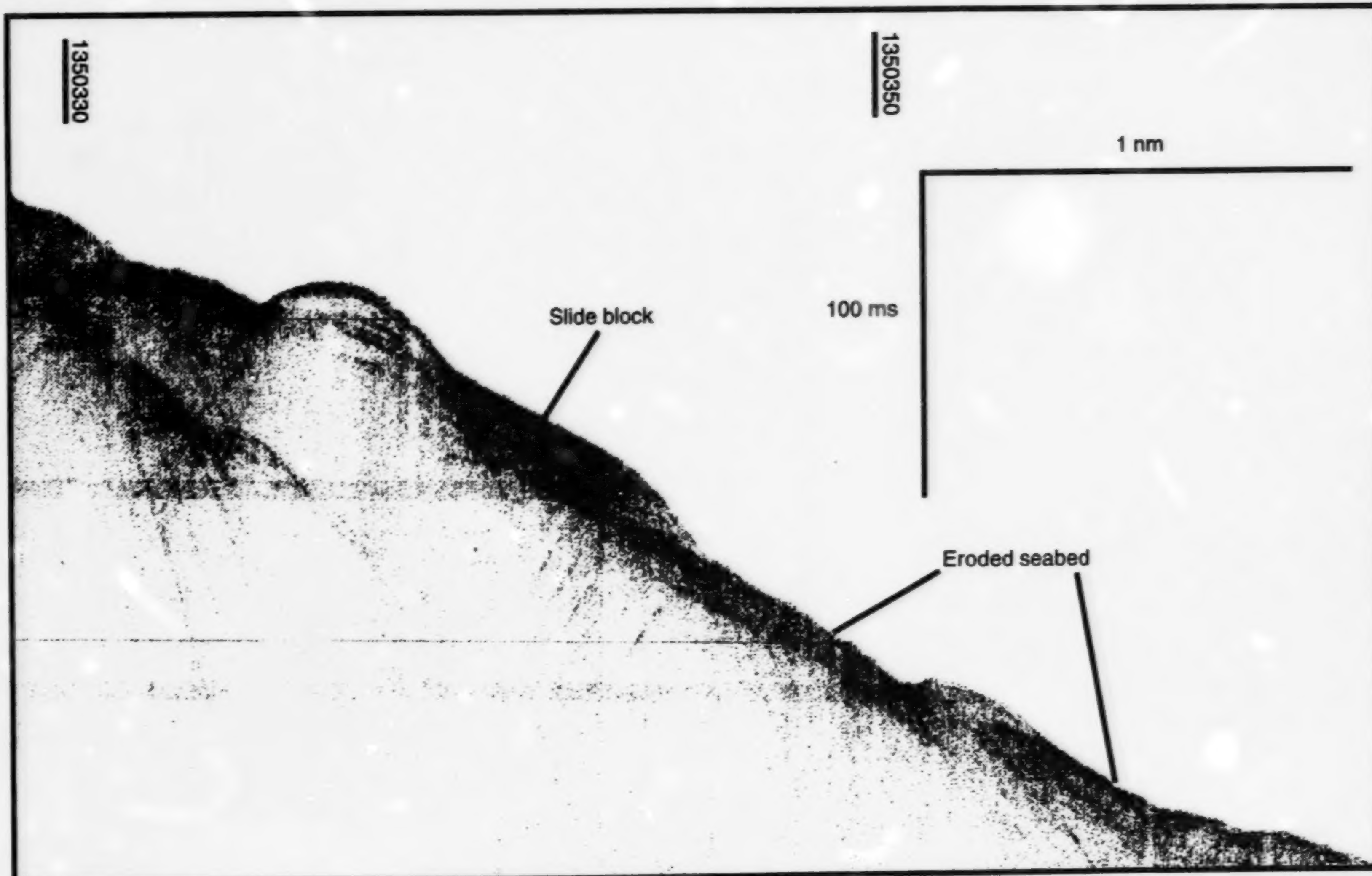


Figure 9 This 3.5 kHz record shows an eroded seabed with a possible slide block.

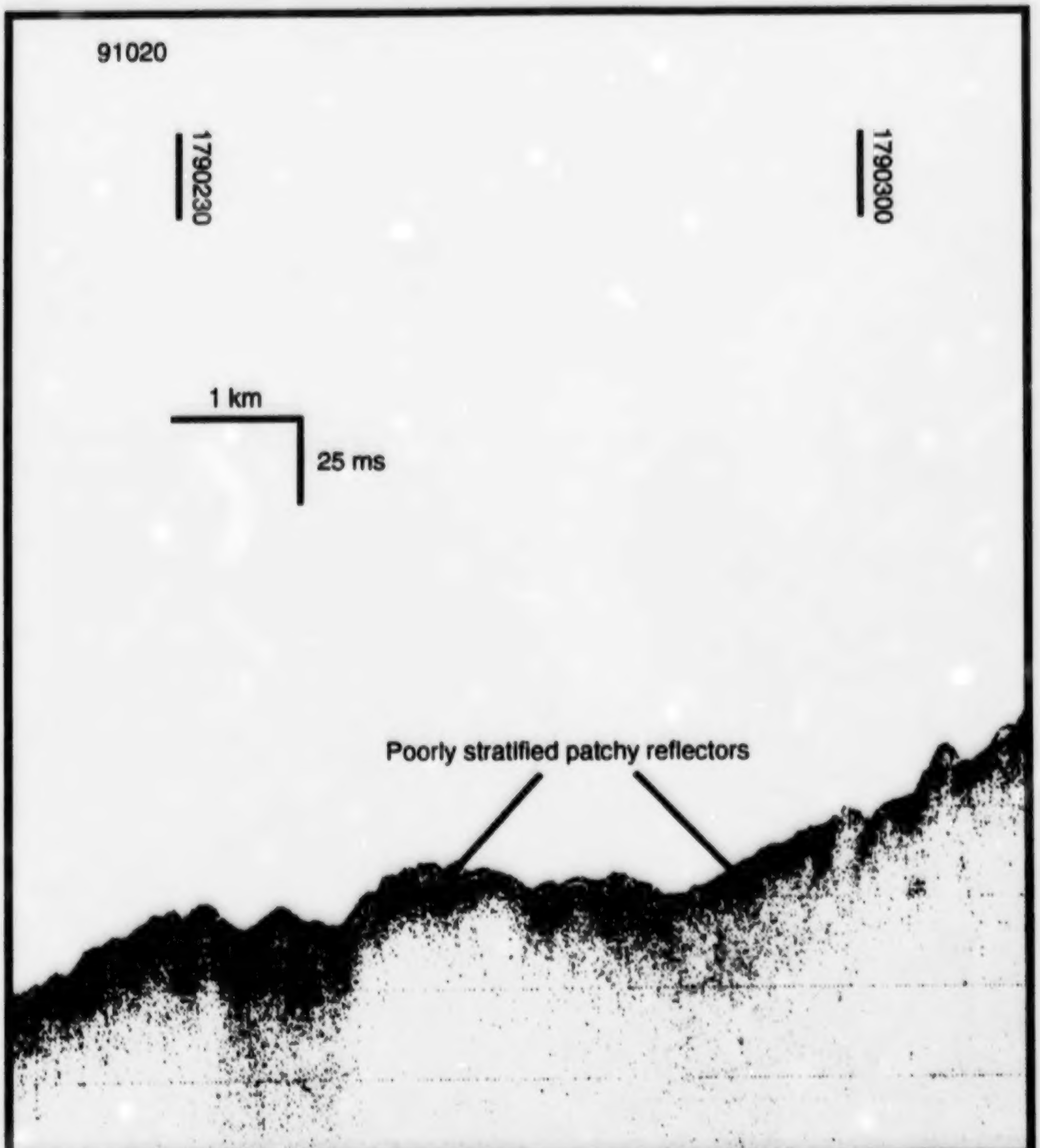


Figure 10 A 3.5 kHz record showing poorly stratified patchy reflectors and hummocky terrain.

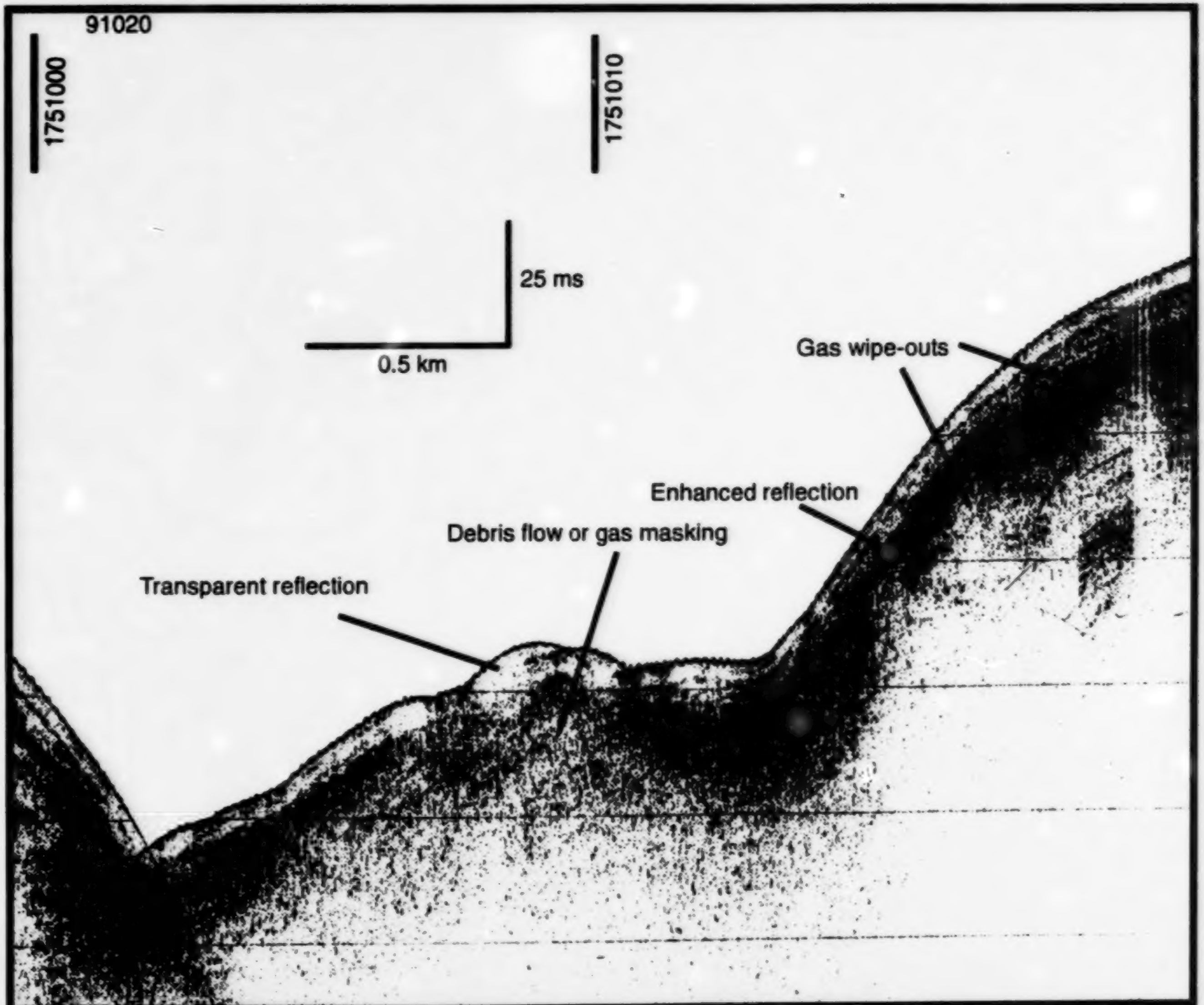


Figure 11 A transparent reflector overlies an intermediate debris flow or gas masking. Gas wipe-outs and enhanced reflectors are found in this 3.5 kHz record.

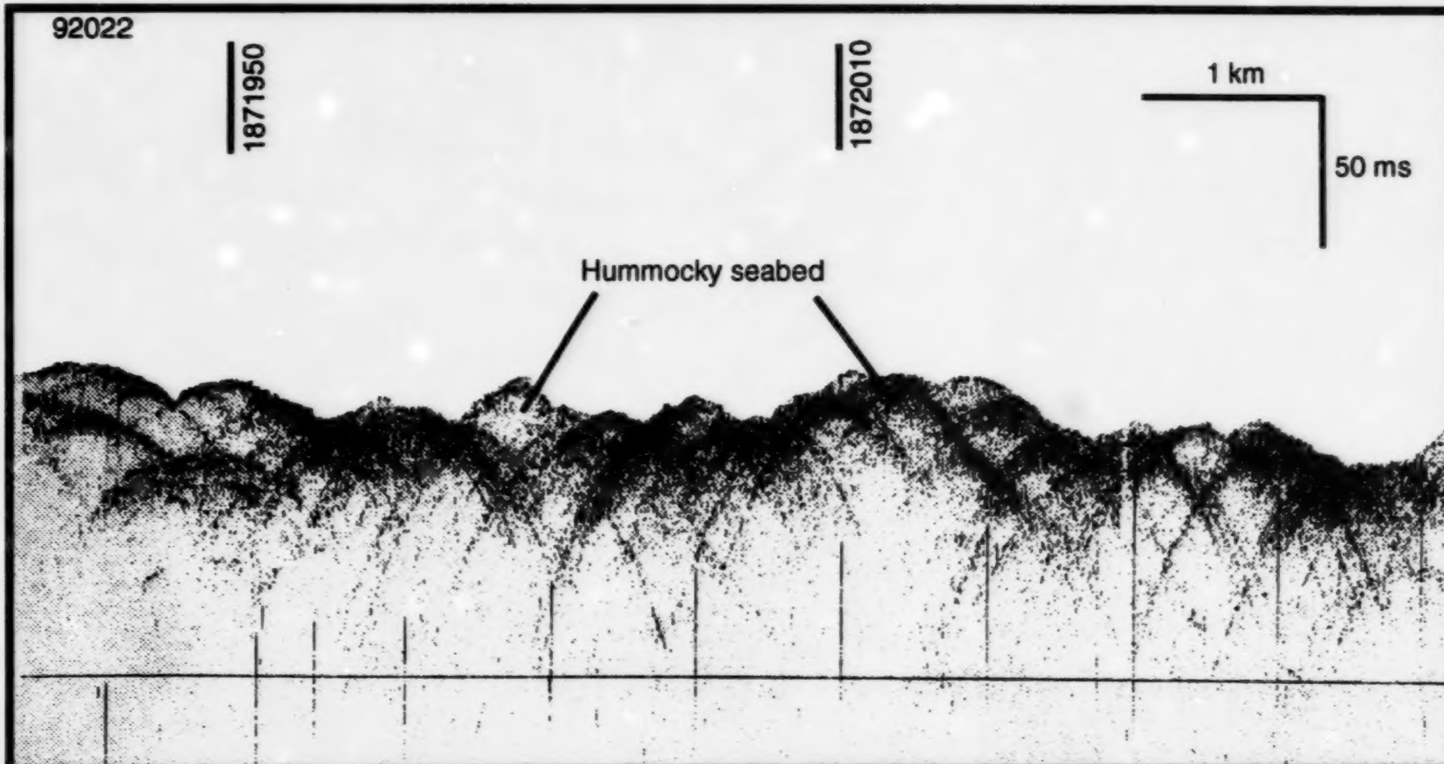


Figure 12 A 3.5 kHz record showing a rough debris flow at the seabed.

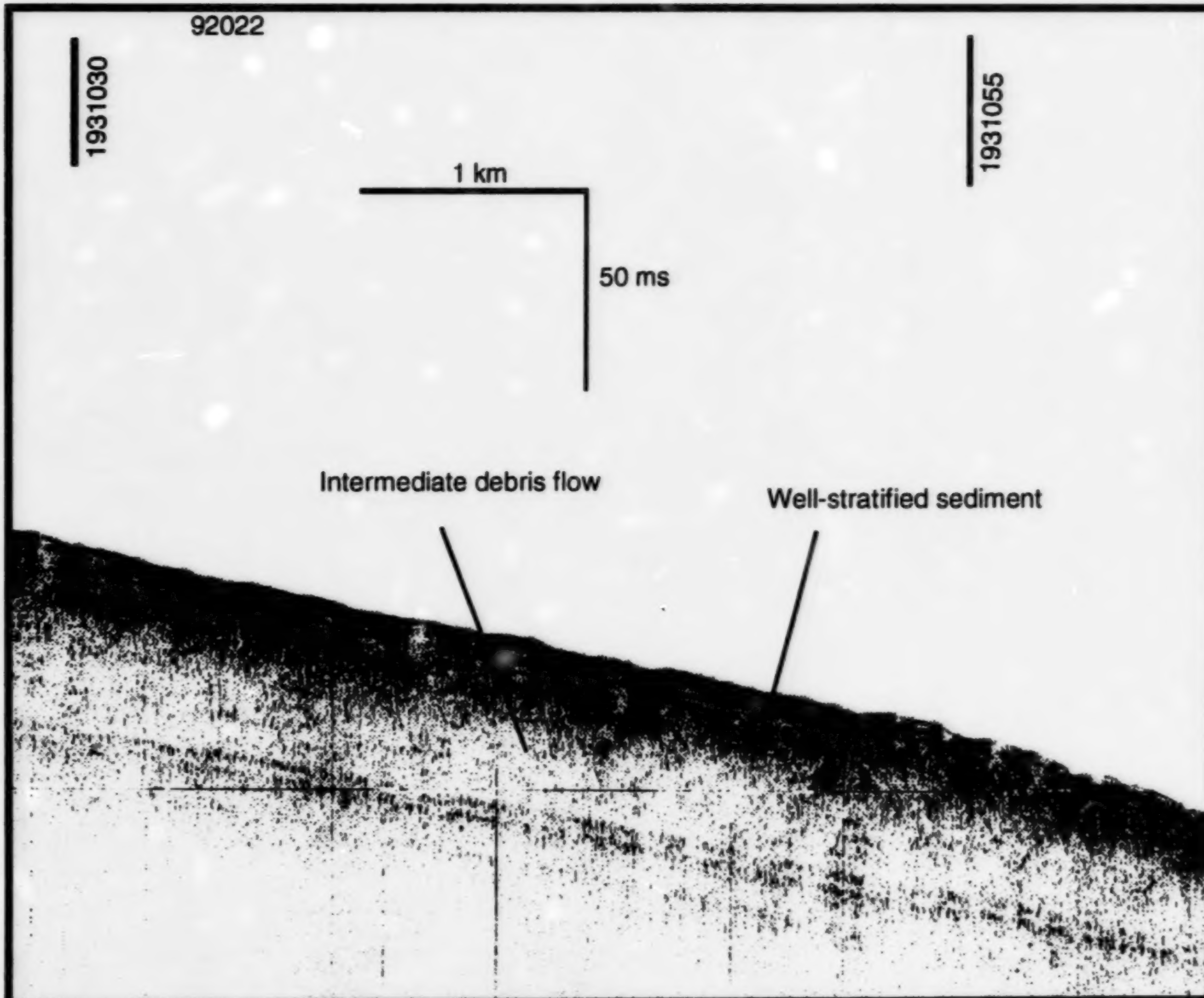


Figure 13  A 3.5 kHz record showing well-stratified sediment overlying an intermediate debris flow.

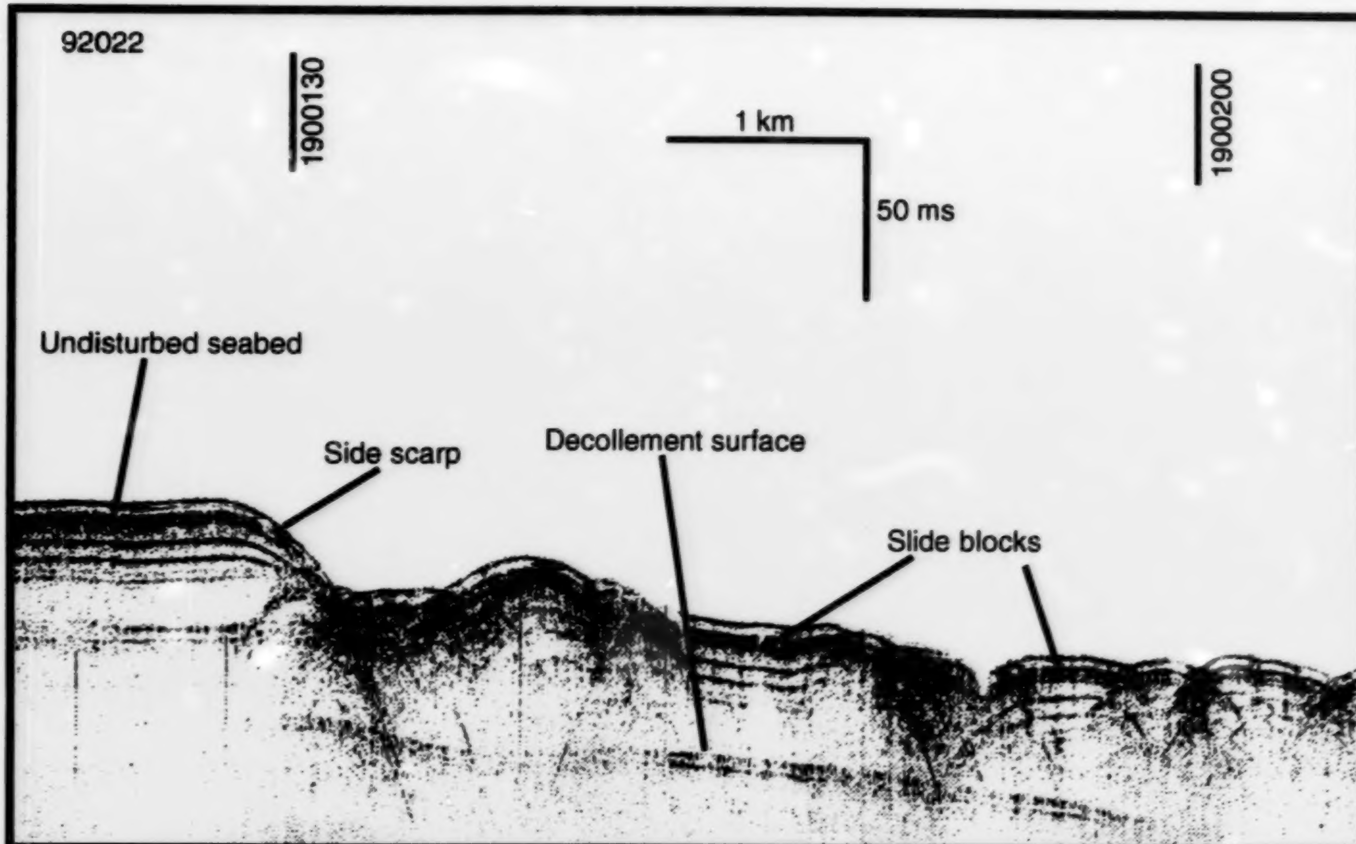


Figure 14  This 3.5 kHz record shows an area of the seafloor with slide blocks and disrupted sediment.

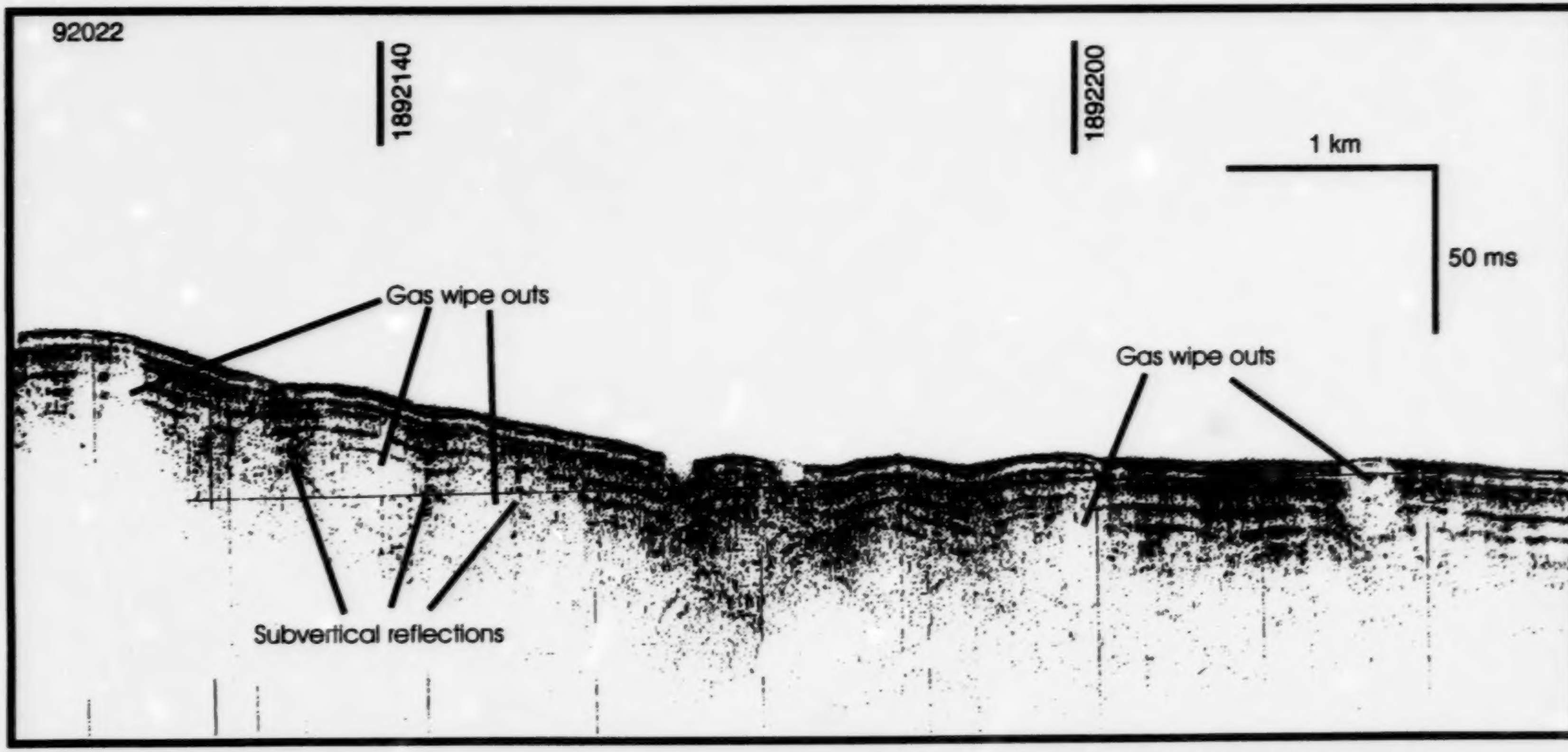


Figure 15 This 3.5 kHz record shows gas wipe outs, and gas induced subvertical reflections, in well-stratified sediments.

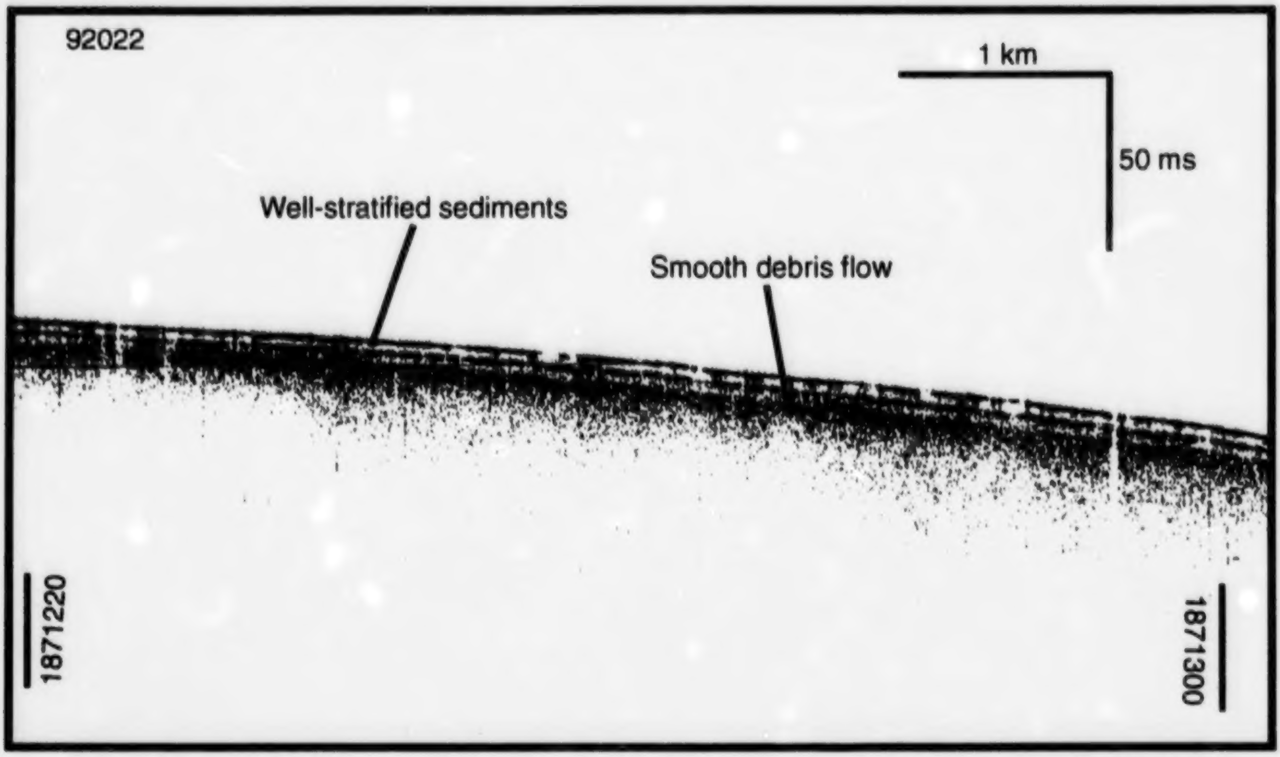


Figure 16 This 3.5 kHz record shows well-stratified sediments overlying a smooth debris flow. The debris flow may be a sandy layer in the subsurface.

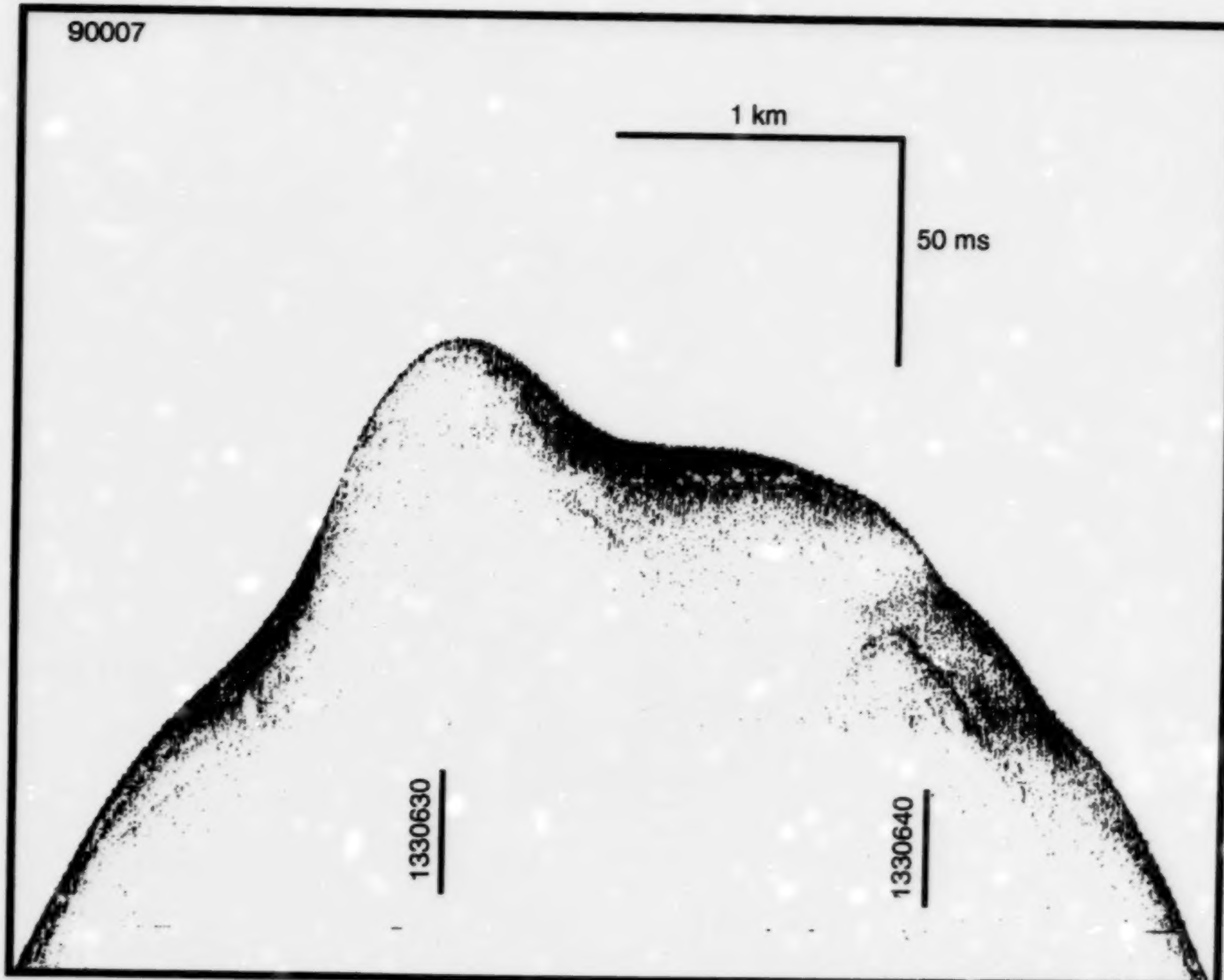


Figure 17 This 3.5 kHz record shows a seamount high with a prolonged strong reflection from the seafloor. The seamount may have a thin sediment cover in places.

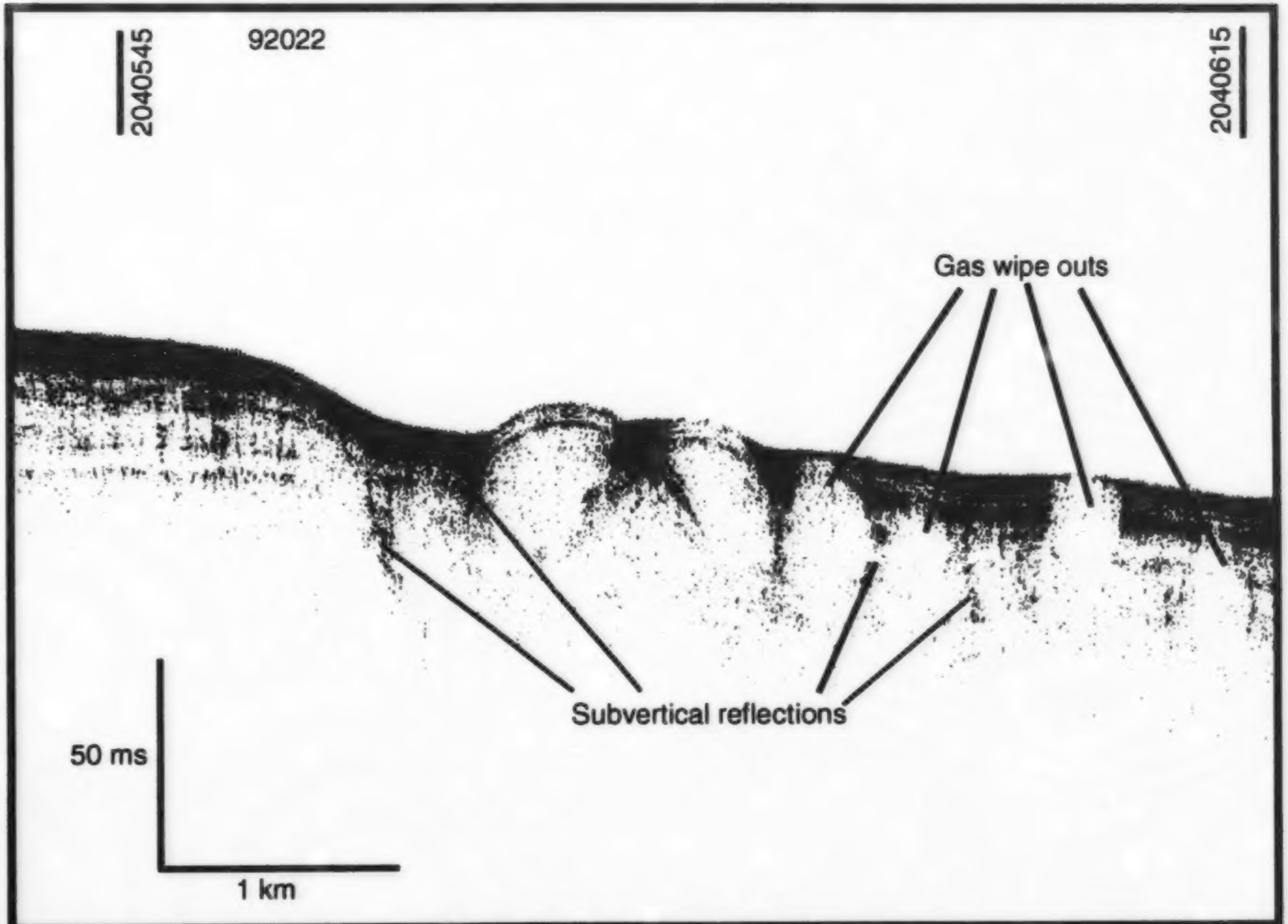


Figure 18 This 3.5 kHz record shows gas wipe outs, and gas inducted vertical reflectors occurring in well-stratified sediments.

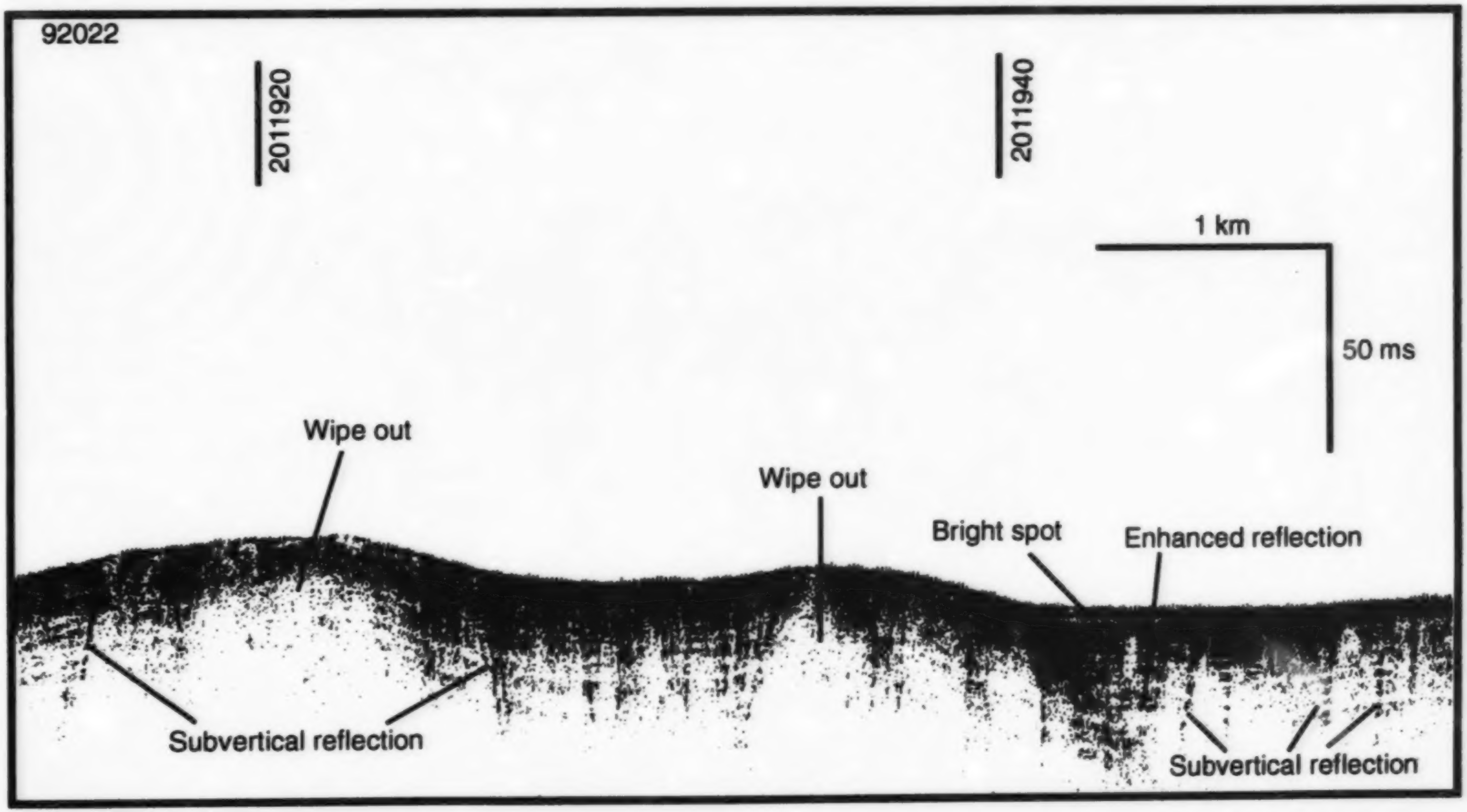


Figure 19 This 3.5 kHz record shows gas induced wipe-outs, bright spots, enhanced and subvertical reflections in well-stratified sediment.

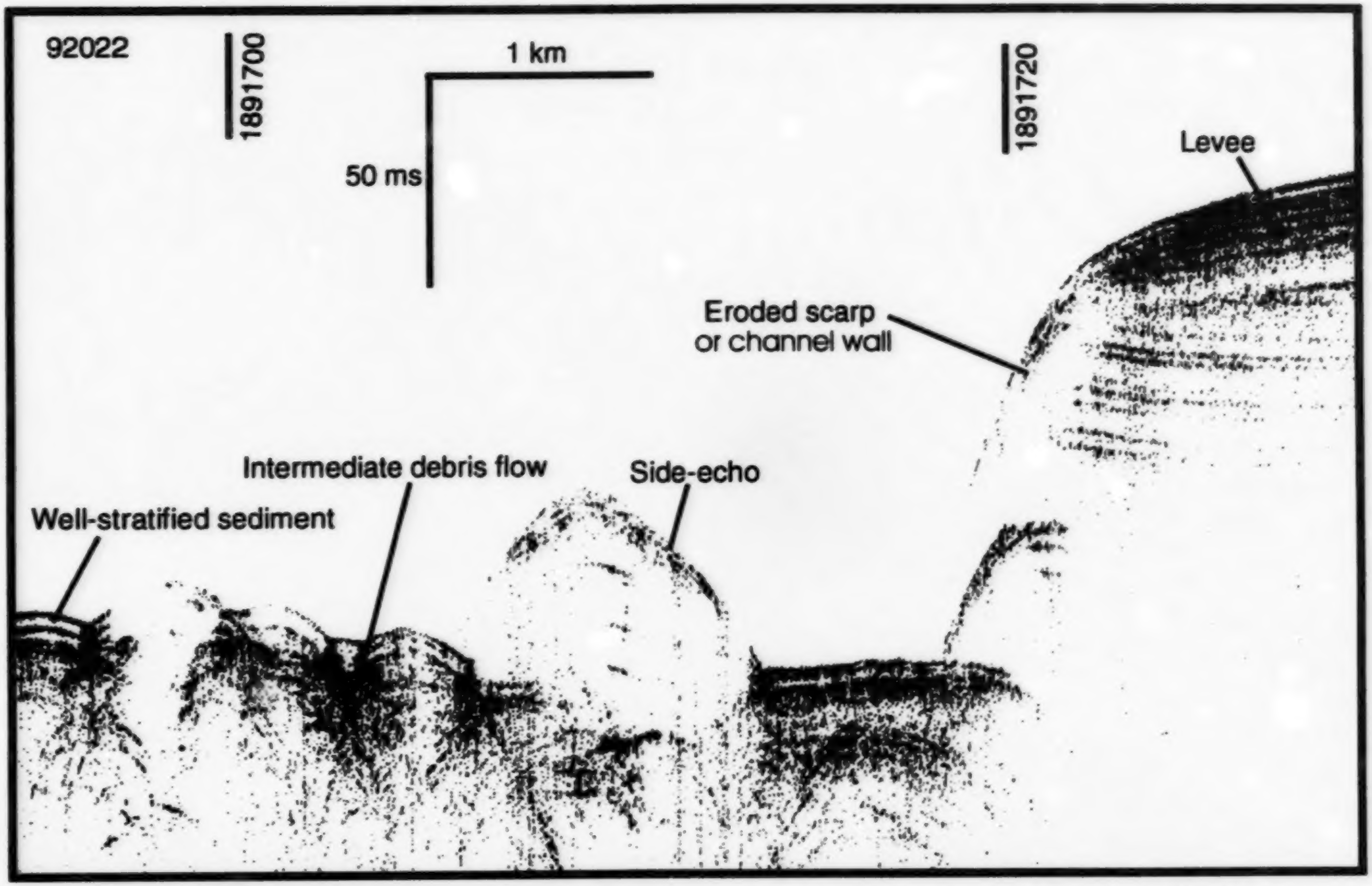


Figure 20 This 3.5 kHz record shows an eroded scarp or channel wall with truncated reflections.

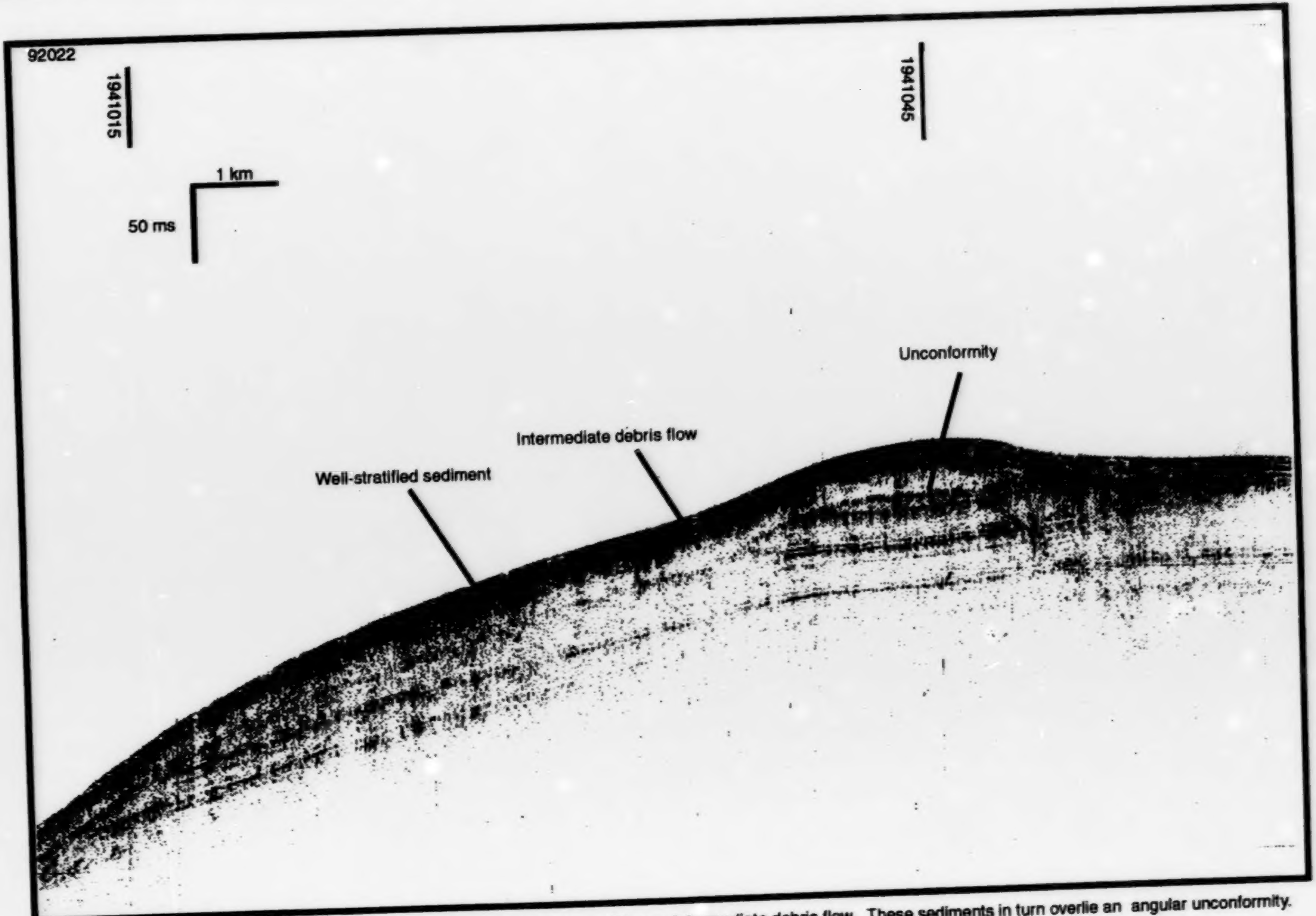


Figure 21 This 3.5 kHz record shows well-stratified sediment overlying an intermediate debris flow. These sediments in turn overlie an angular unconformity.